PLASTECO UN Refugee Shelter Design

Chapter 2: Base Design

Group 1

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1 Summary

From our industrial supervisor, we were tasked with designing a refugee shelter for the United Nation. The shelter would be made up of majority PLASTECO's Smartawood materials and should aim to compete with the UNs existing solutions. Designing the Base, I aimed to create a universal, modular, and structurally sound base for the shelter to be built upon. The base is made of PLASTECO's Smartawood (Plastecowood, n.d.) and allows for the variation in shelter shape and size. The Bases' weight, size and cost were a few of the deciding variables used in designing the base. The Base is assumed to be built on flat ground in a hot climate.

1.1 Introduction

During times of crisis or displacement, UN Refugee shelters are vital in providing safe and liveable accommodation. Providing the refugees protection from the elements, threats and allowing them to have maintain dignity during the tough situations. The UN classifies the refugee shelters into 3 categories depending on the duration of time a refugee is expected to live there as seen in image 1: Emergency, Transitional and Durable. From the current existing solutions for refugee shelters very few have an elevated base. All emergency shelters and most transitional shelters require the occupant to live on a plastic sheet floor or no floor at all. This impacts the standards of living in multiple ways such as a significant heat loss through the floor and little protection against flooding.

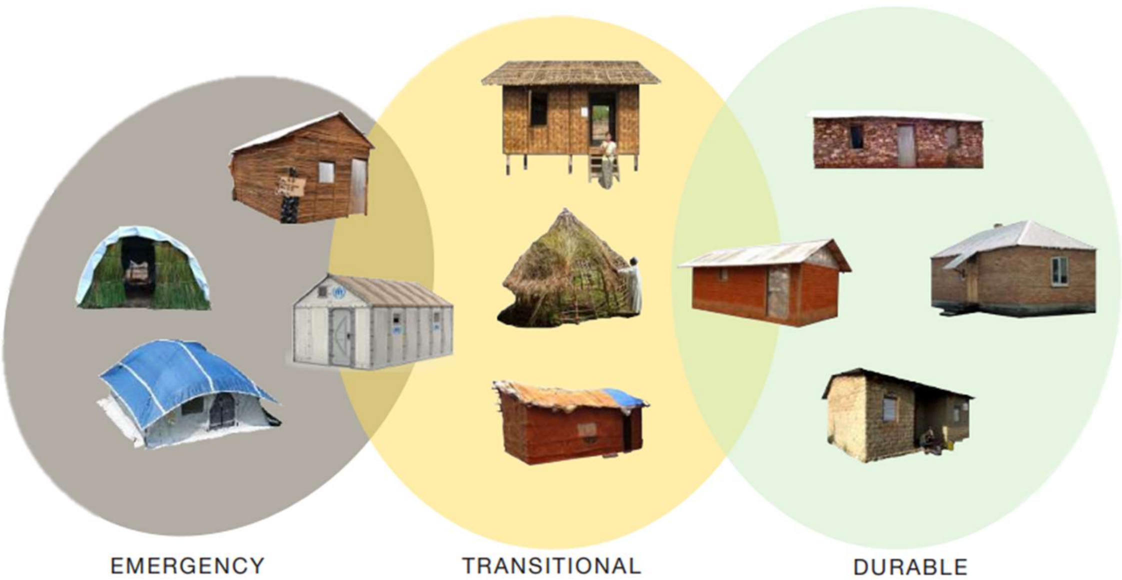

Figure 1 - UNHCR Refugee Shelter Categorisation (UNHCR, 2024)

2. Background Research

To create a new base design for a refugee shelter, I had to investigate the need and wants from both the customer, The UN, and the consumer, The Refugees, whilst also taking into consideration our Industry supervisors, PLASTECO. These needs and wants would define the technical specification for the design of the base.

2.1 United Nations High Commissioner for Refugees [UNHCR]

The UNHCR outlines basic standards of living the shelters need to abide by to be approved. These standards coincide with the Sphere standards (Sphere, 2018) allowing us to create some basic minimum dimension requirements.

2.2 Existing Solutions

To create an effective shelter design for PLASTECO we needed to have a unique selling point and for our subassemblies to be novel. By exploring the existing shelters, we can pinpoint some areas which the current solutions fall short. The UNHCR provide a full catalogue of all shelters (UNHCR, 2016) in use which gave is a good means to start our investigation. The main shelters we used for our comparison was the Better Shelter [*Figure 2*] and the AZRAQ T-Shelter [*Figure 3*]. The Better Shelter being emergency and the AZRAQ T-Shelter being transitional, it gave us a good base comparison for our design.

Figure 2 - Better Shelter (UNHCR, 2016)

Figure 3 - AZRAQ T-Shelter (Fisher, 2014)

2.3 Expert Interview

Our final main source of information came from Dr. Dima Albarda, Member of the research team for the 'Healthy Housing for the Displaced' and a Lecturer at the University of Bath. Dr. Dima was vital in providing us with insight into the lives of refugees. She has published multiple papers on refugee shelters and has interviewed many refugees herself. This gave us insight into the qualitive objectives we wanted to achieve such as the desire for room dividers and having a modular design so the basic emergency shelters could be converted as the duration of stay increases.

2.4 Technical Specification

From this background research we were able to create our technical specification chart for the general shelter and each specific sub assembly.

Table 1 - Technical Specification Chart

Specification	Description	Demand/Wish
The shelter shall meet the UN spacing standards for 4 people	The final design must have a total measured floor space at least $14m^2$ and 2m tall.	Demand
The Shelter can be adjusted for the local customs and norms	Qualitive analysis through UN/Refugee connections to confirm shelter design [Colour, Shape, and style] is appropriate to designated areas customs and religions whilst maintaining a reasonable cost.	Wish
The Shelter should be easy and simple to build on site requiring little prior knowledge.	No individual component will weigh more than 75kg, allowing 3 people to lift it. In addition, it can be assembled with nothing more than a drill and basic tools	Demand
Easy to understand and follow written instructions on how to assemble the Shelter.	Providing step by step instructions of the assembly in simple English.	Demand
Achieve a competitive cost in comparison to the current used shelter solutions by the UN	The final design of the shelter will be compared against the current refugee housing unit costing $22/year/m^2$.	Wish
The shelter should be grade 2 in flammability	The shelter is partially or fully made from fire-retardant materials (>50%) as with accordance to UNHCR standards.	Demand
The internal flooring should meet the external walling with limited gaps to prevent the entry of rainwater.	Base and wall [tongue and groove] to be flush. With a tolerance of +5mm.	Demand
The base can't be easily disassembled from outside to increase safety.	Design should prevent easy disassembly. All fixtures will be concealed using covers or alternate methods.	Demand
The base will be designed to be able protect occupants from floods.	The base of the structure to have a minimum flood resistance of 20cm [Grade 2 of UNHCR rating]	Demand
The base of the shelter should be able to support 4 people.	The base structure will be able to support an axial load of ~4 x 80kg people standing on it	Demand

3 Concept Generation

For the design process we went with a triple diamond approach consisting of divergent and convergent phases. This allowed the development of the design along with the constant feedback from both our industry supervisor and our expert interviewee creating a user centred design. For the ideal process we would have worked with the refugees and a UN representative to develop the design. However, this fell outside of our time scope for the project assigned.

3.1 Design Methodology

We started our design process with a divergent phase where in each subassembly we researched additional restrictions specific to our designs and collated inspiration from alternate products currently available onto a mood board. We then utilised the 635 Method (Finder, n.d.) as an idea generation method to come up with creative, novel, and alternate ideas to the problems. My mood board and 635 idea board can be seen in Figures 4 and 5 respectively.

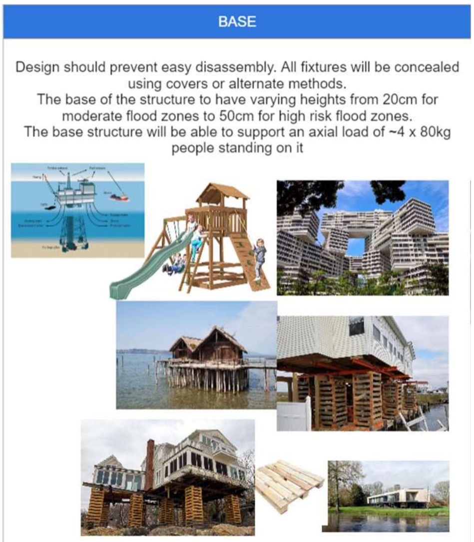

Figure 4 - Miro Mood Board for the Base

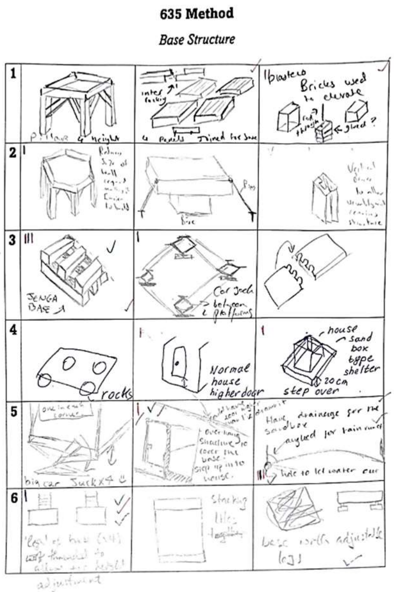

Figure 5 - 635 method for Base Ideation

Once the ideation phase was over, we created a weighted matrix seen in table 2 and voted on the designs which fitted our requirements and would be worth developing and investigating further. Using these Ideas the first concept could be created in the convergent phase of design.

Table 2 - Pairwise comparison matrix for the Base

	Strength	Durability	Weight	Aesthetics	Novelty	Cost	Ease of Use	Total
Strength	-	0	0	1	1	1	1	4
Durability	1	-	0	1	1	1	1	5
Weight	1	1	-	1	1	1	1	6
Aesthetics	0	0	0	-	0	0	0	0
Novelty	0	0	0	1	-	0	0	1
Cost	0	0	0	1	1	-	0	2
Ease of Use	0	0	0	1	1	1	-	3

Ranking	
Weight	Most Important
Durability	
Strength	
Ease of Use	
Cost	
Novelty	
Aesthetics	Least Important

3.1.1 Initial assumptions

For our initial design we had to establish a few assumptions. The first being that the base would have a relatively flat ground to be built upon, this allowed me to assume the bottom of the base to be flat. We made this assumption as with the existing shelters also assume a flat terrain. The second assumption which was outlined in the technical specification is that the base could be built by 3 unskilled workers and a drill would be provided to secure parts. To design a secure base it would require onsite fixings hence a drill being provided. The third assumption made is that the shelter would be built in a hot climate. This gave us our minimum specifications for floor space and weight requirements as the UN state different requirements for hot and cold climates.

Other assumptions that are made regarding the sustainability of the base is that the PLASTECO Smartawood material is 100% reusable when the shelter is being disposed of and that the main environmental impact would be in the transportation of the base. Allowing us to have an edge on current shelters being made of less environmentally friendly materials.

3.2 Iteration 1

For my first design of the base, I went with a 4m x 4m floor plan using 16 1m x 1m meter pallets. This achieved a $16m^2$ bringing it past the minimum requirement outlined in the technical specification.

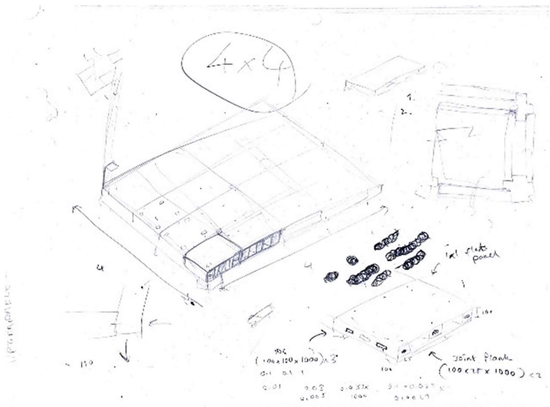

Figure 6 - Hand-drawing of Design 1

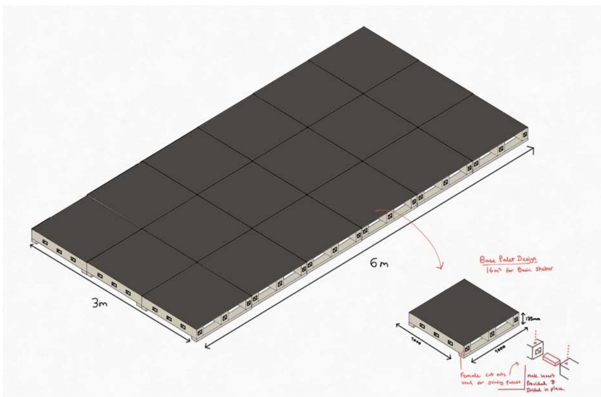

Figure 7 - Electronic drawing of Design

The pallets would require additionall machining to create a female slot in the ends of each supporting plank and 3 in the sides. This would mean each pallet had 3 slots on each side allowing for a male smartawood insert to be added to join the pallets together. Upon reviewing this design it was found that PLASTECO were unable to manufacture the slots in the plans in addition to the difficult nature of joining the pallets. The design also lacked flood protection coming in at only 125mm tall.

3.3 Iteration 2

For the next design, the overall dimensions of the base were changed to 3m x 6m having a total floor space of 18m^2. It was decided for ease of transportation the pallets would be 2m x 1m creating fewer pallets to be moved during assembly. The tops of the pallets were also swapped for Tongue and groove boards which are already manufactured by PLASTECO compared to the thin panels in the first iteration. In addition to this the base beams were increased in size to bring the whole design over the 200mm minimum as stated in our specifications.

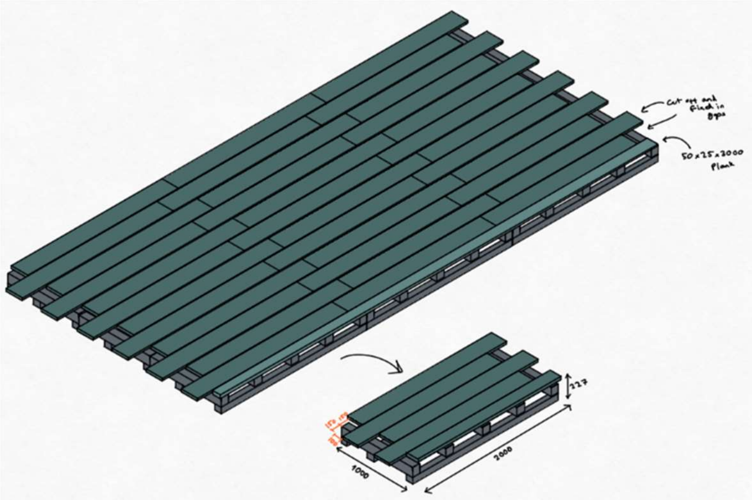

Figure 8 - Electronic drawing of Design 2

3.4 Iteration 3

Upon review we believe that design 2 would cause a lot of difficulty when building the base on site, with planks needing to be cut to create a uniform base. To change this, we suggested reverting back to using a panel on top the pallet. These panels would need to be manufactured externally at an increased cost, but they allow the pallets to be uniform. In Design 3 the pallets are joined using a metal joining plate to ensure the base is secure.

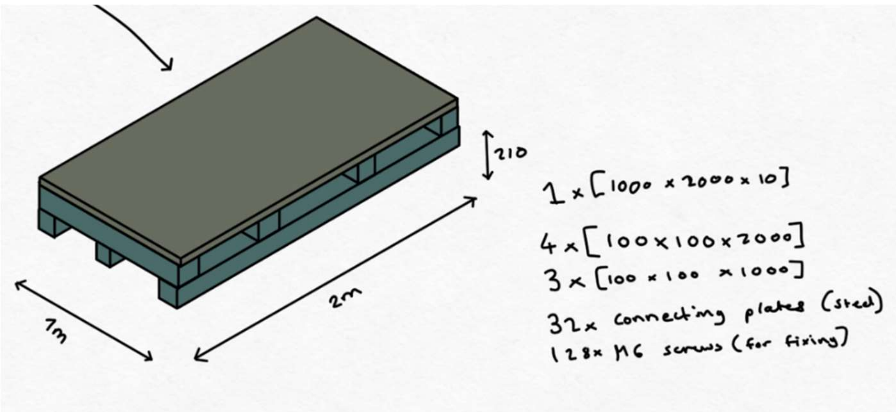

Figure 9 - Electronic drawing of Design 3

4. Final Design

The final design consists of 9 2m x 1m pallets built from Smartawood beams and tongue & groove boards. The pallets are uniform allowing the entire shelter to be modular and customisable. The final design is 227mm tall achieving a grade 2 according to the UNHCR in flood resistance.

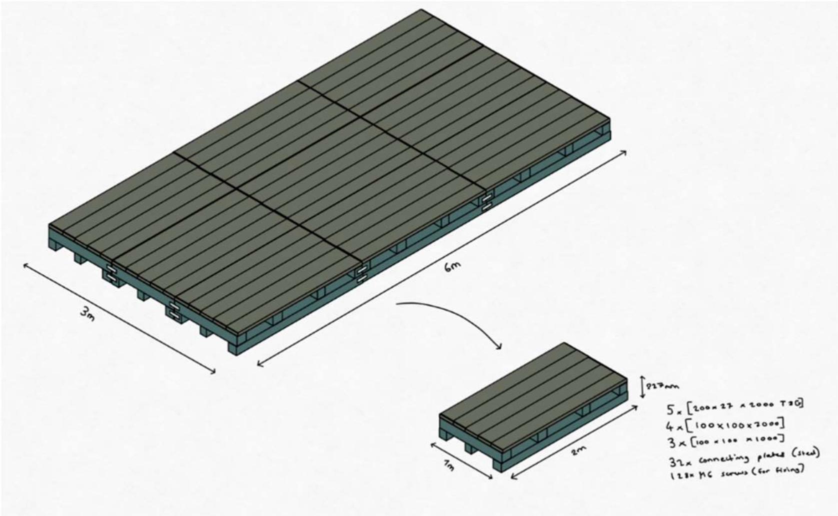

Figure 10 - Electronic drawing of Final Design

The pallets can be organised in any shape to create dynamic living spaces as requested by the occupants. The base beams will be a dark black colour as they are standard for the PLASTECO production. For an additional cost new colours could be introduced or alternatively the Tongue and groove boards could be painted at the factory before assembly allowing the design to be adjusted for local customs improving the quality of life for the occupants.

Another feature of the final design is the flush edges. This allows the walls to overlap creating a waterproof seal around the base of the product which was a concern raised to us by our industry supervisor.

When comparing the Mass and prices of the iterations there is very little difference however the ease of build and uniformity of pallets dictates that the final design is the most effective in achieving our objectives.

Table 3 - Cost and weight comparison

Concept	**Total Mass (kg)**	**Total Price (£)**
Design 2: Overlap	1386	1,386
Design 3: Panel	1080	1,080 + EMC
Final Design: T&G	1386	1,386

[EMC = External Manufacturing cost]

The weight of each pallet comes out to around 142kg meaning it can be easily carried by 2/3 people. The Pallet shape also allows them to be transported using forklifts if available further easing the assembly of the base.

4.1 Final Base B.o.M

Table 4 - Bill Of Materials for Final Design

Description	Dimensions	Quantity	Link
PLASTECO T&G	200x2000x10	45	Link
PLASTECO Beam	100x100x2000	36	Link
PLASTECO Beam	100x100x1000	27	
MAGNODUR NAILING PLATES	170x3x30	32	Link
Screws	M6x50	128	Link

5. Discussion

The PLASTECO supplier will be basing cost estimations off Mass, with every ton of PLASTECO manufacturing cost at £600 and sales price of £1000. This equated to about a 40% gross profit margin. The overall material cost of the base coming in at £1386 is a significant cost however with the rapid build of the base it allows it to compete with the current options as there is no alternative. The base of the shelter is in a market of its own, As the better shelter and AZRAQ T-Shelter do not include a floor/base in their shelter design. As the Base is separate from the main shelter it could also be used as the grounds to build alternative shelters. In climates that expect high rainfall the base could be deployed raising any pre-existing tent like structure and then repurposed during dry seasons.

Given that PLASTECO already manufacture pallets, the feasibility of creating the base out of a pallet like structure is possible. In addition to being the only emergency/transitional shelter with a raise base for flood resistance, the uniform pallet design also allows the shelter to be modular. Current designs are a fixed size and shape, allowing for little room segregation or the development of the shelter into more of a home. With the Smartawood design, when more room is required, the base can be extended using more pallets. This could include but not limited to creating cooking areas, raised external platforms, cleaning facilities, and sleeping facilities. The modular design allows the refugees to maintain dignity and live a higher quality of life when needing to stay in the camps for extended periods of time.

5.1 Development

Overall, the development of the design has been successful, working through iterations receiving feedback and implementing it into the next design. The final design meets all the target requirements outlined at the start of the investigation however still requires further investigation to ensure that it is safe and secure.

Given the restricted timeframe for this investigation there are a lot of testing that would be required before presenting the base design to the United Nations. The first being Finer Elements Analysis on the base joining plates, ensuring that the base can support the weight of a family of 4 at all points. Furthermore, analysis into the fixings used would need to be explored to ensure they will not fail under cyclical loading and under harsh climate conditions.

If more time could be invested into the design of the base, I would recommend exploring iteration 3 and the use of a Smartawood panel. This would allow the overall weight of the base to be reduced which contributes to a large portion of the overall shelter weight. To do this a cost/benefit analysis would need to be done to determine whether PLASTECO could invest in the infrastructure to press the panels in house removing the external cost.

5.2 Sustainability

Given that the PLASTECO Smartawood material is made using non-recyclable plastics, for every ton of Smartawood used equated to around 700kg of carbon is saved. This means that the only carbon emissions from the Base design is the transportation of the base to the refugee site. All PLASTECO materials can be repurposed or remanufactured when the base isn't required anymore and using metal fixing brackets means there are no waste products produce from the base design.

6. Conclusion

To conclude the base design is effective in achieving the outlined specifications and achieving a novel and competitive design in the refugee shelter market. More in depth analysis is required further convince UN officials of the reliability of the base. However, all the testing required is feasible for PLASTECO to continue researching to achieve an effective modular base design.

7 Appendix

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